Comparative Life Cycle Assessment of Foldable Jerrycans and Plastic Buckets

Project: Accelerating the Reduction of the Environmental Impact of Humanitarian Action

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Introduction

Objectives and scope

This analysis aims to enhance understanding of the item's impacts on climate, human health, and plastic leakage. It also identifies potential levers to reduce these impacts. However, assessing the feasibility of implementing these levers falls outside the scope of this project.

By no means is it suggested that life-saving assistance to the most vulnerable populations across the world should be reduced for decarbonisation purposes. Effective emissions and other impact reductions should not result in any reduction in the quality, quantity or timeliness of assistance, but rather should explore ways to reinforce or maintain aid, while identifying low-carbon, sustainable, and resilient alternative options.

Objectives and scope

Objectives:

- To establish GHG Emission Factors for **20L foldable jerrycans & 14L plastic buckets** adapted to the humanitarian context.
- To analyse the environmental impact of the jerrycan's life cycle and identify key levers for impact reduction through a comparison with plastic buckets as a **water container.**

Scope & System Boundaries:

- **Cradle-to-grave*** system for the assessment of impact across the complete life cycle.
- The materials, production, distribution, use and disposal of the product are in scope of the study.
- Any additional processes after production are not in scope e.g. unplanned storage, etc.
- The procurement of the packaging is modelled, upstream activities related to the packaging are out-of-scope.
- The study focuses on one unit of the product and does not include larger-scale supply activities i.e. shipping per container, etc.

*In life cycle assessment, **cradle-to-grave** refers to evaluating a product's environmental impacts from raw material extraction through manufacturing, use, and final disposal. In contrast, **cradle-to-gate** focuses only on the stages up to the product's departure from the manufacturing site, excluding use and end-of-life phases.

Methodology

The results are calculated following the Environmental Footprint 3.1 indicator system in two categories:

- **Climate Change**: Global Warming Potential (GWP100)
- **Impact on Human Health**:
    - Human Toxicity: Carcinogenic and Non-carcinogenic
    - Ionising Radiation
    - Particulate Matter Formation
    - Photochemical Oxidant Formation
  - Weighted using the approach detailed in the EF methodology – with a percentage assigned to each sub indicator (see reference)
  - Normalized for one citizen so as to aggregate and represent as a single score for human health

Plastic leakage: Experimental projection of the amount of plastic leaked into nature via mismanagement of waste

References:

"European Platform on LCA | EPLCA.". https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

Joint Research Centre (European Commission), Alessandro Kim Cerutti, Rana Pant, and Serenella Sala. 2018. Development of a Weighting Approach for the Environmental Footprint. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/945290

End-of-life

This study aims to model the impact differences between various waste management methods tailored closer to humanitarian contexts. The following end-of-life options were modelled in the analysis, as appropriate:

- **Open dump** (unmanaged)
- **Open burning** (unmanaged)
- **Unsanitary landfill** (minimal management)
- **Sanitary landfill** (managed site)
- **Municipal incineration** (managed plant)
- **Recycling** (as modelled)

For plastics, the differences in measured impact between each end-of-life scenario are similar. (For more info on the impacts and sources of end-of-life impact measurement please see annex.)

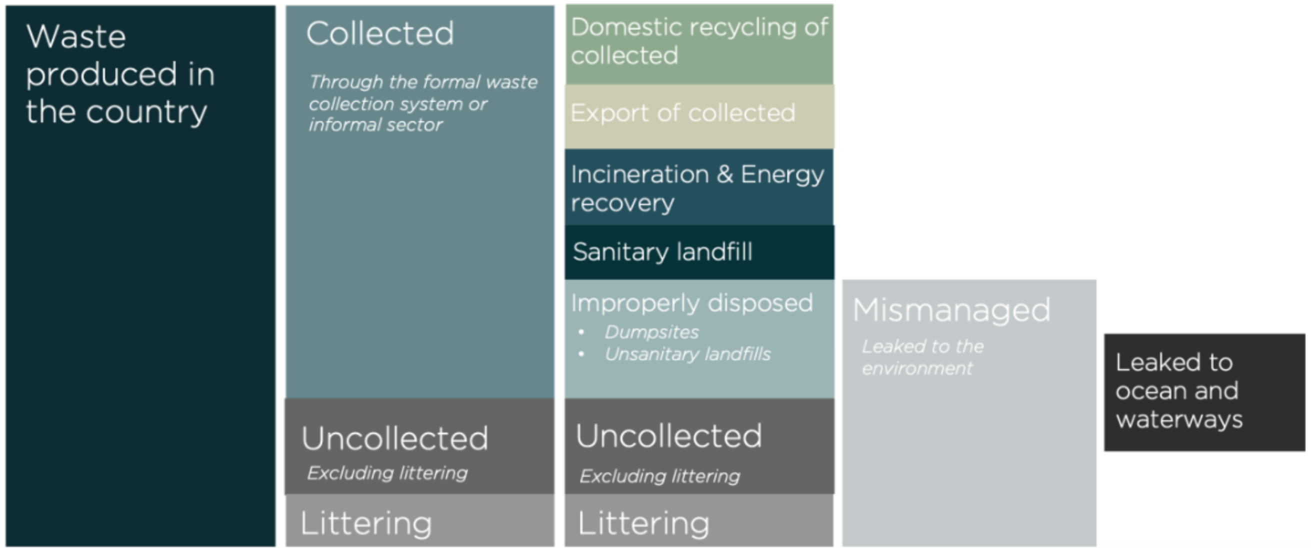
According to the LCA methodology, the analysis of greenhouse gas (GHG) emissions (Global Warming Potential)—is limited to a 100-year timeframe. As a result, any additional impact from plastic degradation in landfills occurring beyond this period is neither measured nor compared to other waste disposal methods.

Plastic leakage

This project aims to estimate the mismanaged waste that may occur at the end of life of products distributed by humanitarian organisations.

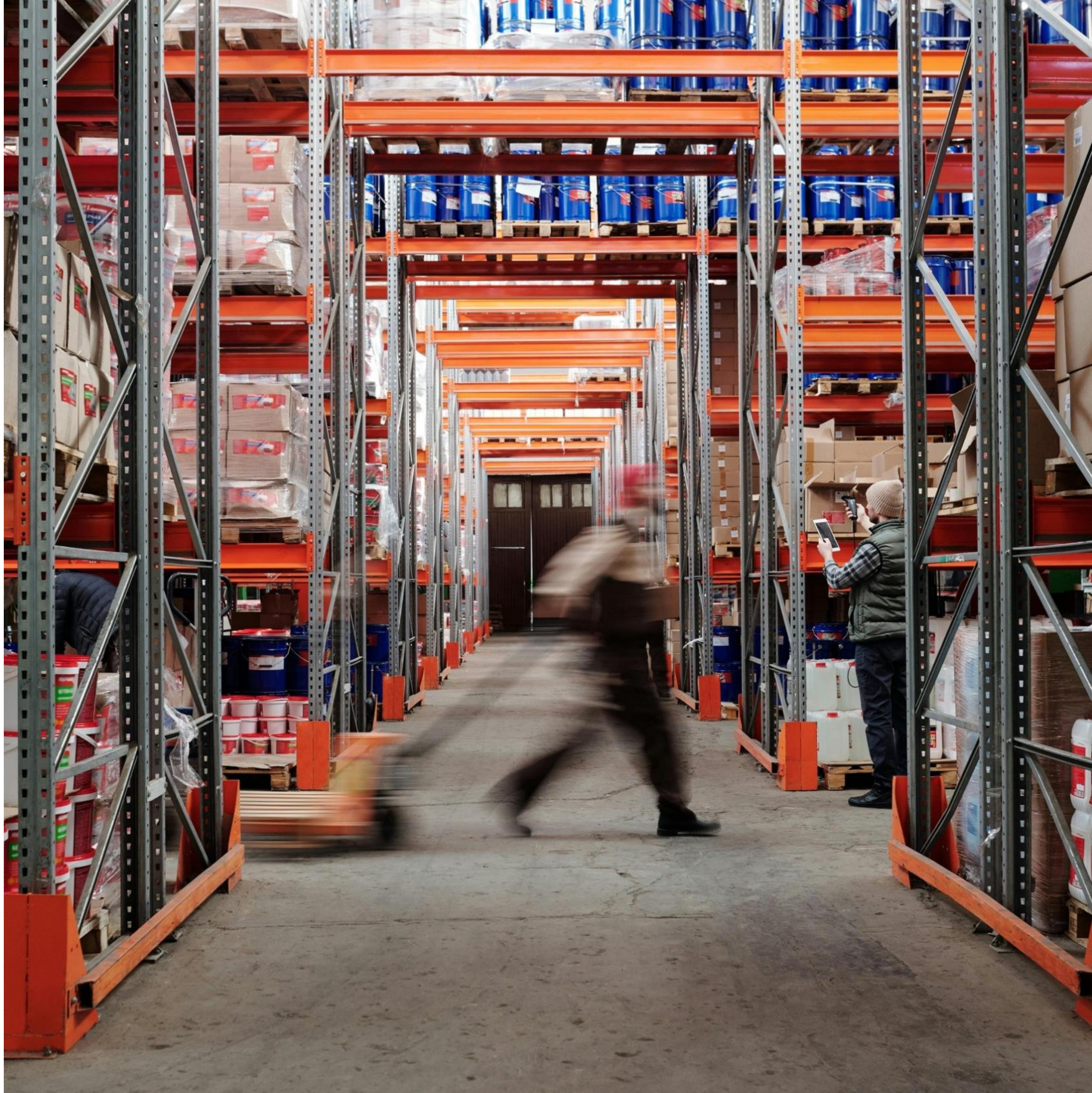
The modelled scenarios are analysed for plastic leakage by selecting the waste management method that is modelled and calculating the projected leakage (or lack thereof) due to the same.

For more information, please refer to: "Global Plastic Environmental Analytics Platform." Plasteax. https://plasteax.earth/.



Source: EA – Earth Action

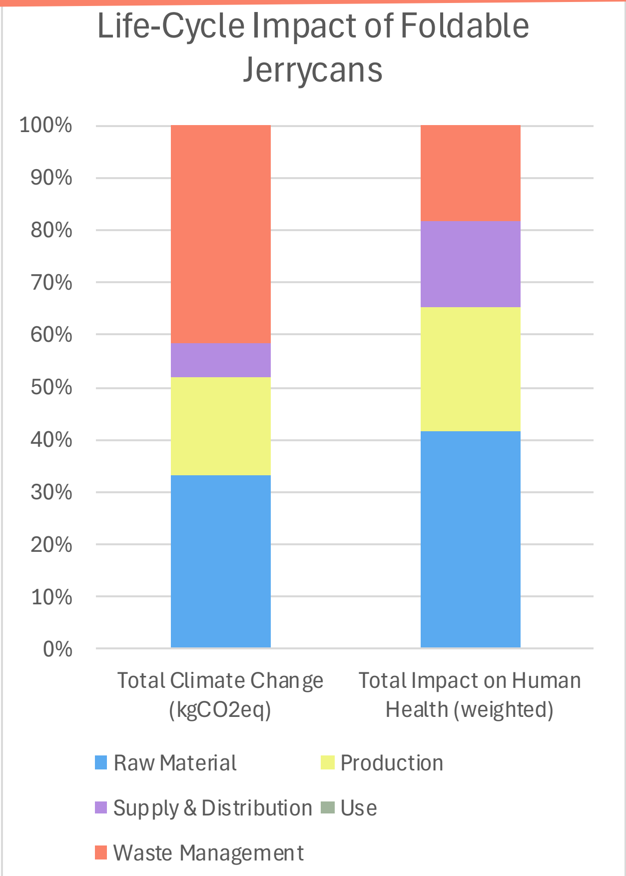
LCA Results



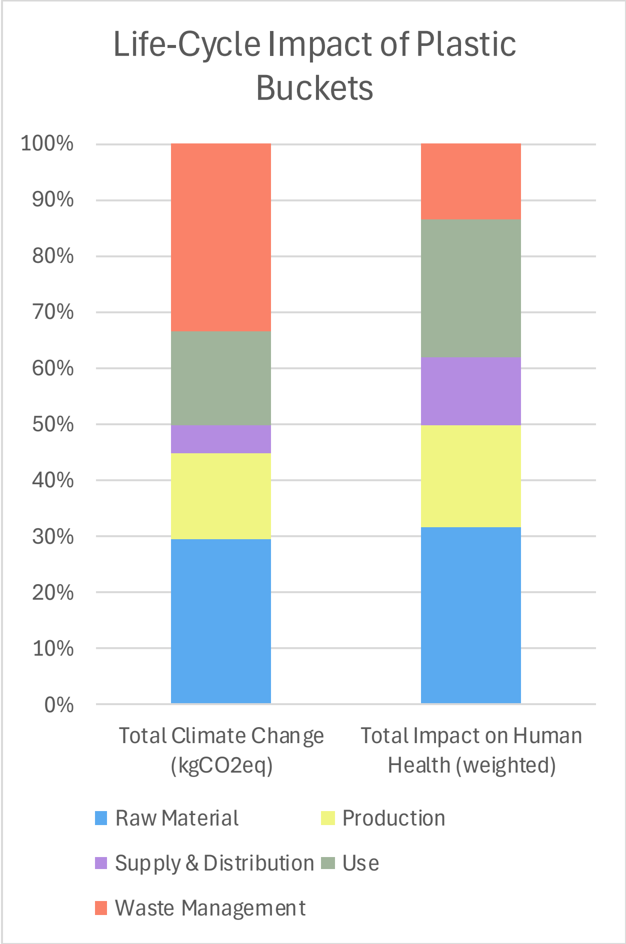
Key Product Parameters & Assumptions

LIFE-CYCLE STAGE	PARAMETER	DESCRIPTION OF MODEL FOLDABLE JERRYCANS	DESCRIPTION OF MODEL PLASTIC BUCKETS
GENERAL	Field Context	This analysis aims to compare two existing options for containers to transport water for drinking, cooking, and washing—foldable jerrycans and buckets, to be supplied in bulk during emergencies	
Raw Material	Bill of Materials	Virgin LDPE	Virgin HDPE
	Packaging	Carton & Duct Tape	Carton & Duct Tape
Production	Manufacturing Location	Manufactured from locally sourced materials in China and transported to the field by ship	
	Manufacturing Processes	Blow Moulding	Blow Moulding
Supply & Distribution	Transport Chain	TRUCK SEA TRUCK	
Use	Lifespan	3 months	5 years
	Usage Processes	None (lifespan too short)	Washing with tap water and soap twice a year
Waste Management	Product Disposal Method	Open burning	Open burning
	Packaging Disposal Method	Open dumping	Open dumping

Baseline Results



- Both products are made of polyethylene, and raw material production represents a significant share of their environmental impact—33% of GHG emissions and 42% of human health impacts for jerrycans, and 30% and 32%, respectively, for buckets
- Unlike jerrycans, buckets include a use phase (washing to keep it clean), contributing 17% of GHG emissions and 24% of human health impacts, which reduces the relative impact of other life cycle stages for buckets
- At end of life, both products are modeled to be burned in open pits. This disposal method accounts for 42% of GHG emissions and 18% of human health impacts for jerrycans, and 34% and 14%, respectively, for buckets
- Plastic leakage
  - For the product, no leakage as it is assumed that the product is incinerated
  - The packaging is considered to be cardboard, leading to no plastic leakage for this product



Emission factors		Unit
Cradle-to-grave	2.56	kgCO2eq/unit
Cradle-to-gate	1.33	kgCO2eq/unit

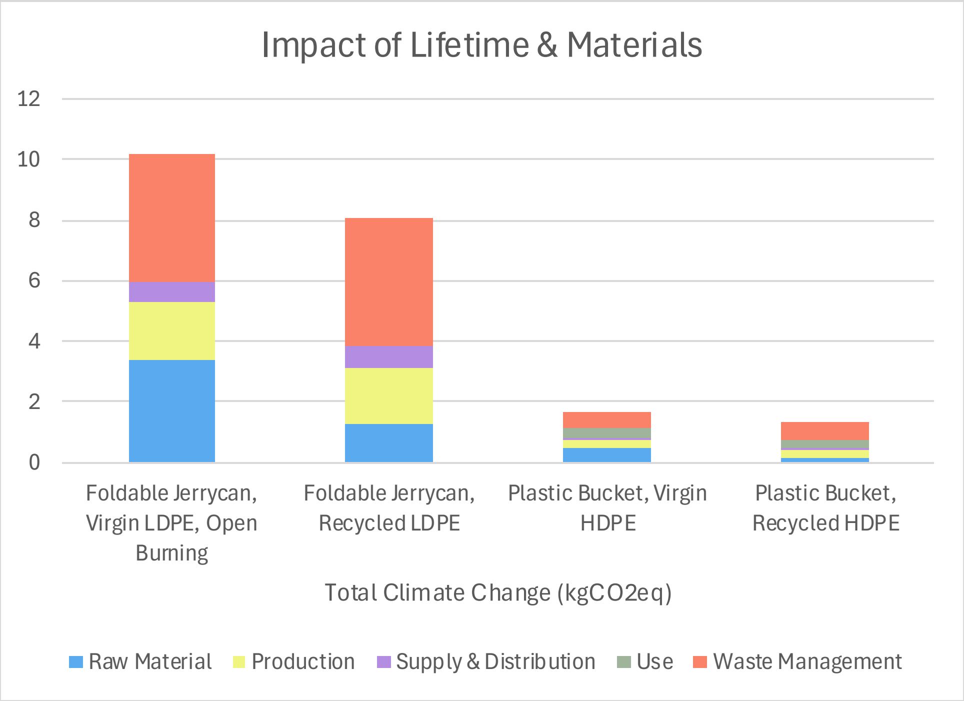
Emission factors		Unit
Cradle-to-grave	8.40	kgCO2eq/unit
Cradle-to-gate	3.77	kgCO2eq/unit

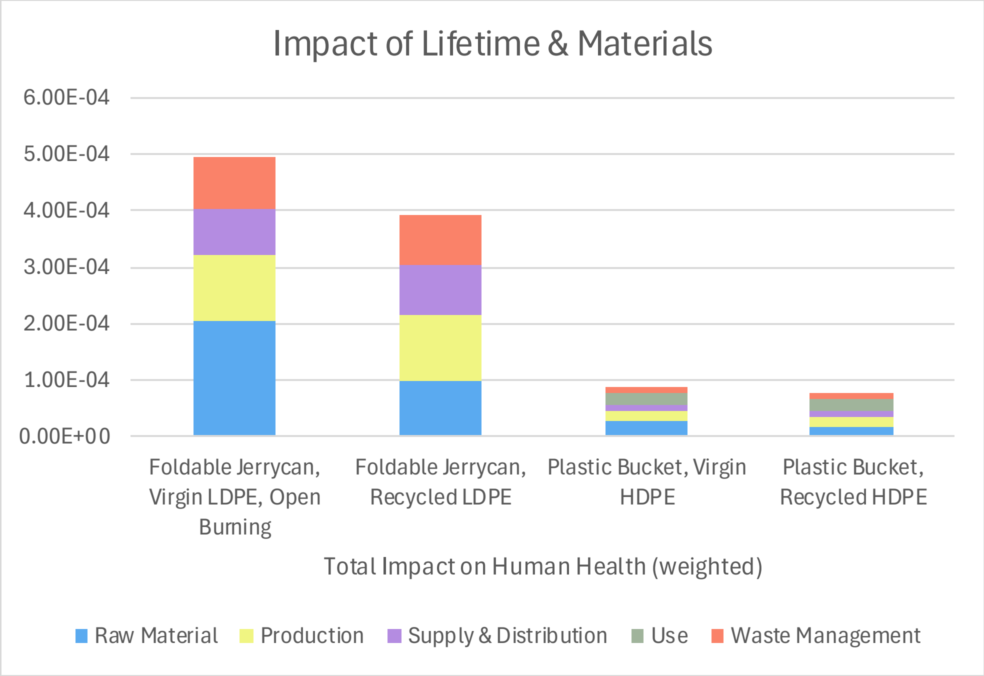
Functional Unit: Storage of 20L of water for 1 year

Variations per lifecycle stage

	Raw Material	Production	Use Life	Supply & Distribution	Waste Management
Baseline	Virgin LDPE (Jerrycans)	Average energy mix	No washing	TRUCK – SEA – TRUCK from China to sub-Saharan Africa	Open Burning
	Virgin HDPE (Buckets)	Solar energy for production	Washing twice a year		Municipal Incineration
	Recycled LDPE (Jerrycans)				Sanitary Landfill
	Recycled HDPE (Buckets)				Collection to recycle in Europe (Bucket)

Lifetime & Materials

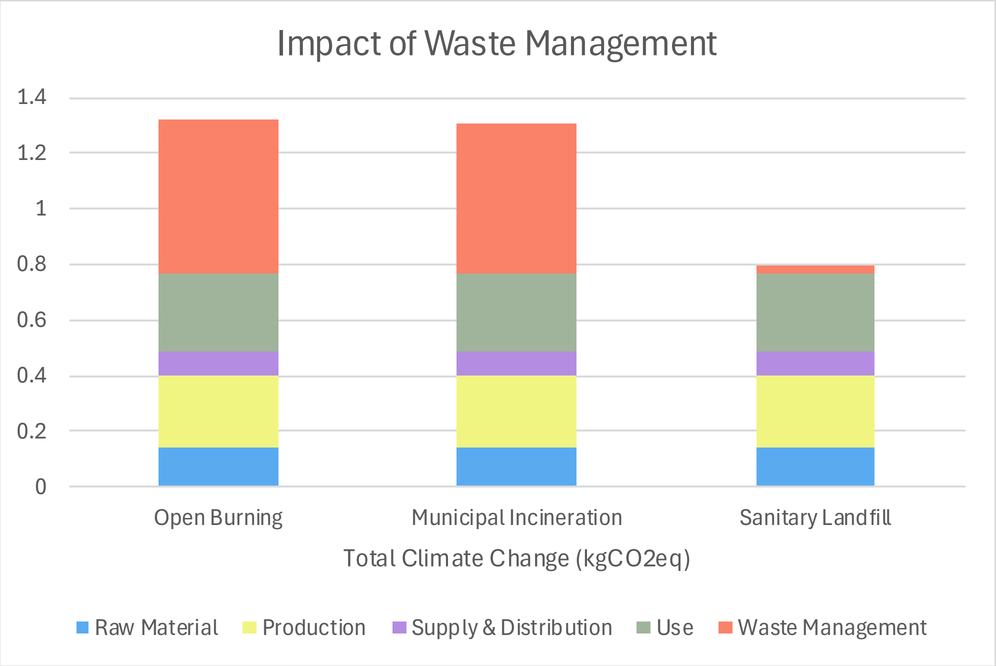


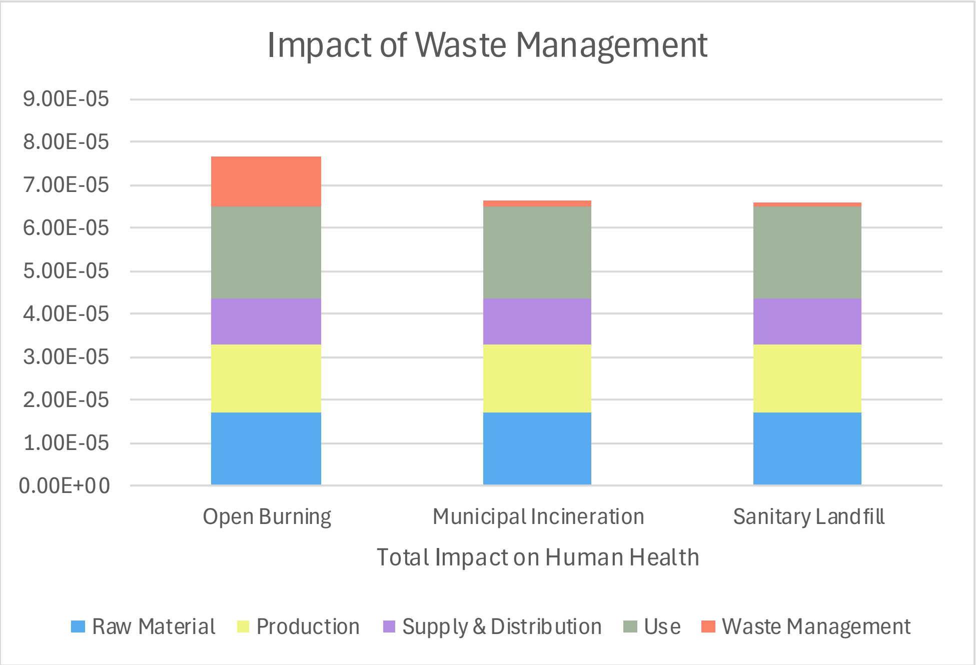


Lifetime and Materials

- The lifespan of the two products plays a big role in the analysis due to the fact that jerrycans last a very short time (3 months in our model) and buckets, made from sturdier material, last several years. The reduction in impact between the jerrycans and buckets when measuring for one year of use for carrying 20 litres of water (which requires 4 20L jerrycans or 1.43 14L buckets) is **84%/82%** in GHG emissions and impact on human health respectively.
- Substituting virgin material for recycled materials, further shows a reduction of **2-5%** for the buckets in both categories, while for jerrycans the substitution brings about a reduction of **~20%** in both categories
- In general, a long-lasting product is more impact efficient, no matter the material.

Waste management

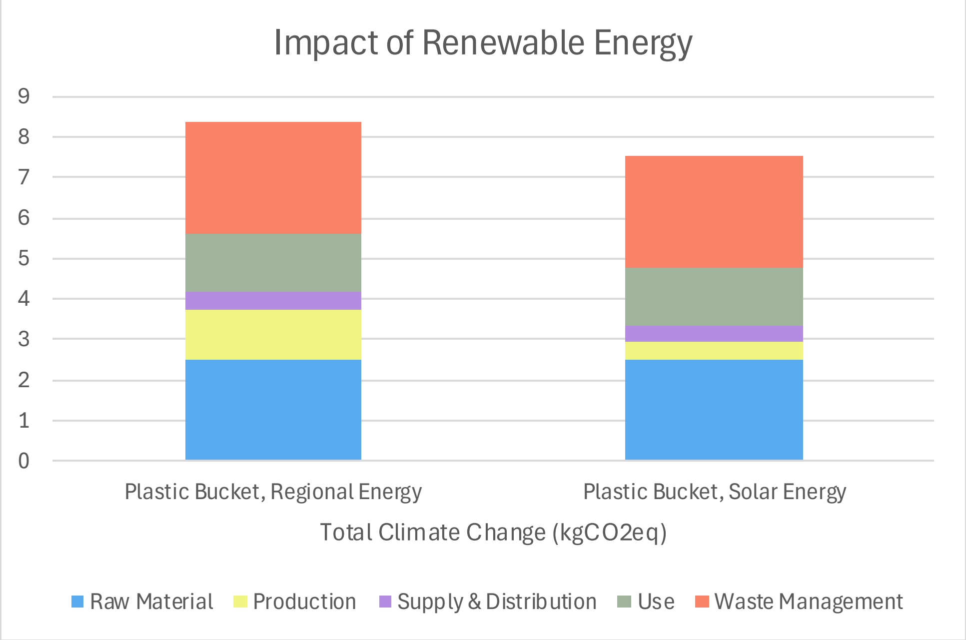


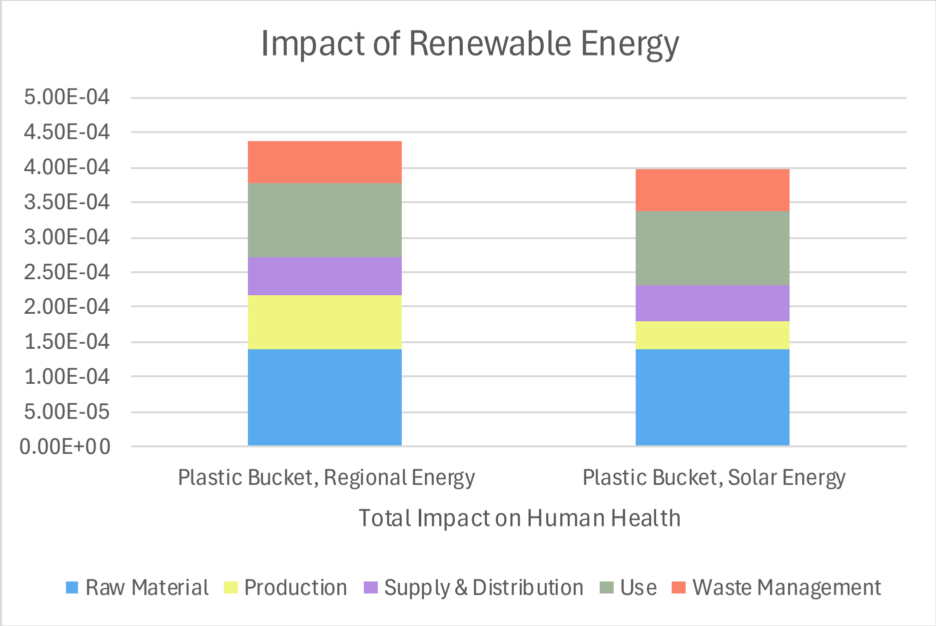


Waste Management

- Burning plastic waste in a municipal incineration plant rather than openly will not reduce GHG emissions but will reduce impacts on human health if the plant has the adequate filters - taking the improved product variation, i.e. Recycled HDPE Bucket, we can see a reduction of **~1%** in GHG emissions, but a reduction of **~13%** in impact on human health
- Sanitary landfills however reduce **~40%** GHG emissions from the baseline model of open burning as well as **~14%** impact on human health, making sanitary landfills the preferred waste management method within the scope of the LCA (see slide 6 for more information).

Low-carbon energy





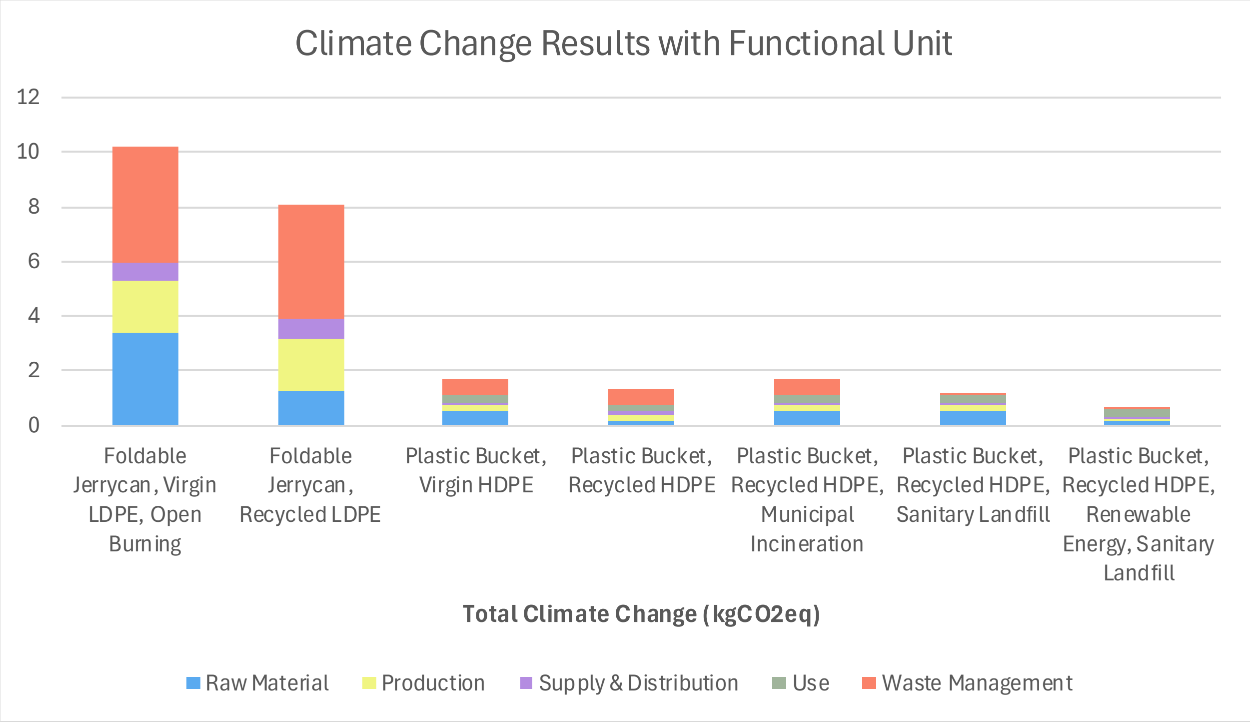
Energy for Production

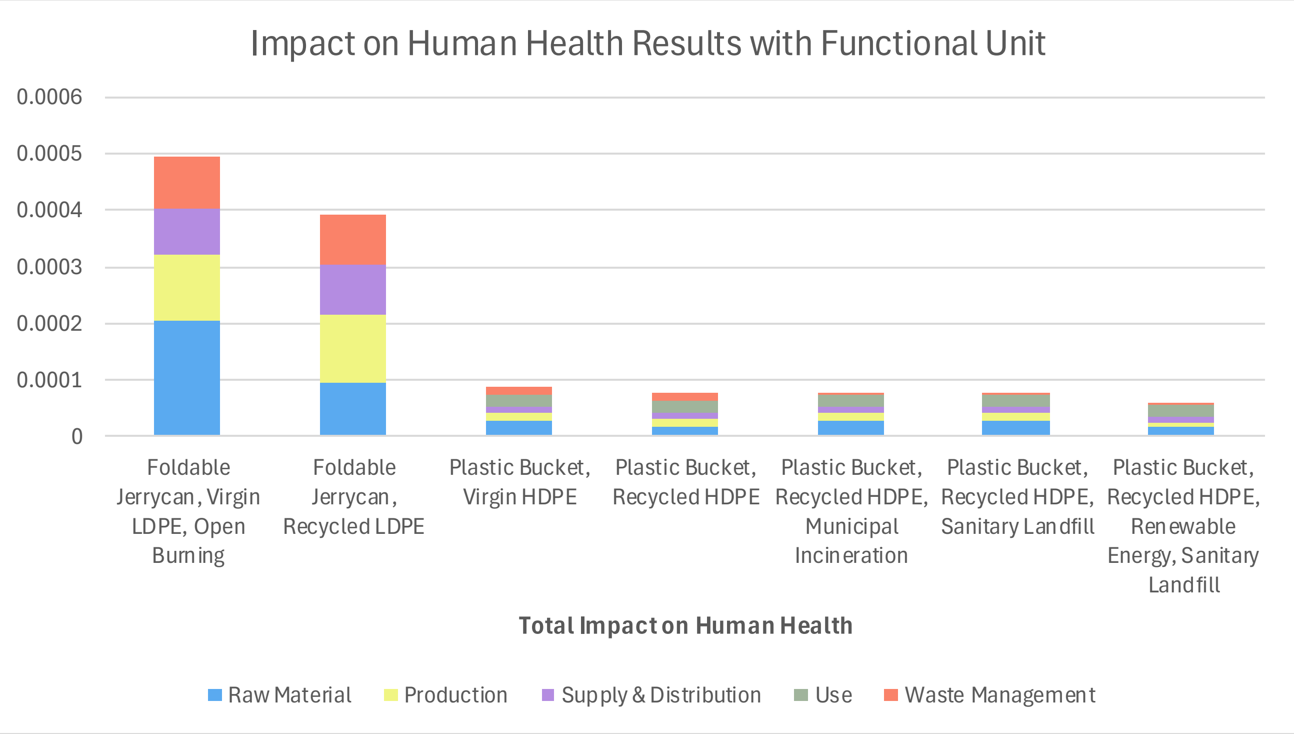
- Switching the energy source for the production of the electricity or the heat used during the production phase can lead to a reduction of environmental impacts. This is particularly the case when energy sources intensive in fossil fuel are replaced with renewable energy sources
- For **HDPE buckets**, switching from the **average energy mix** to **solar energy** results in a **10% reduction in GHG emissions** and a **9% reduction in human health impacts**. This **relatively modest improvement**, compared to other products analysed, is largely because the **raw materials, use phase, and end-of-life** stages account for a **greater share of the total impacts.** .
- Combining this benefit with other actions e.g. moving to recycled material can, however, amplifiy the reduction.

Impact Assessment: All Results

Functional Unit: Storage of 20L of water for 1 year

Jerrycans needed: 4
Buckets needed: 1.43





Key conclusions of comparative analysis

- In satisfying the function of longer-term water storage, replacing the container with an option with a longer lifespan (i.e. replacing jerrycans with buckets) can reduce large amounts of the environmental impact caused by the product itself. Further improving the sustainability product – in this case buckets – can cause even greater impact reductions.
- For plastic buckets, combining the reduction from using good quality recycled HDPE, renewable energy for production, and sanitary landfill as a waste disposal method – provides the below impact reduction as compared to using virgin LDPE jerrycans.
  - ▼ 94% climate change
  - ▼ 88% impact on human health

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Thank you!

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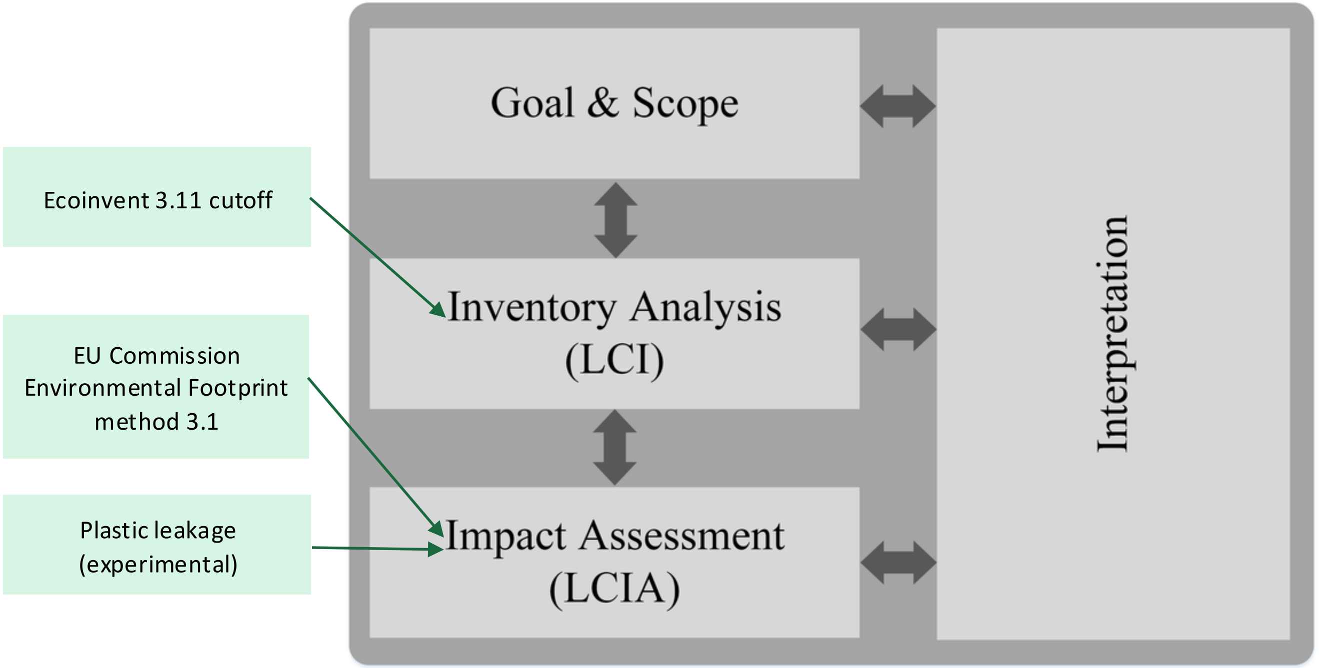
Methodology

The primary database used is Ecoinvent 3.11

The studies utilize the data from the **cut-off system model which allocates the entire impact of the material to its primary user** without any 'rewards' for its potential for being recycled.

Consequently, any recycled materials do not carry the burden of the impact of the primary use of the material and rather track the impacts from the recycling process onward.



Life cycle assessment (LCA) steps according to ISO 14040, 14044, and 14067.

References:
"Ecoinvent v3.11." n.d. Ecoinvent. https://ecoinvent.org/ecoinvent-v3-11/

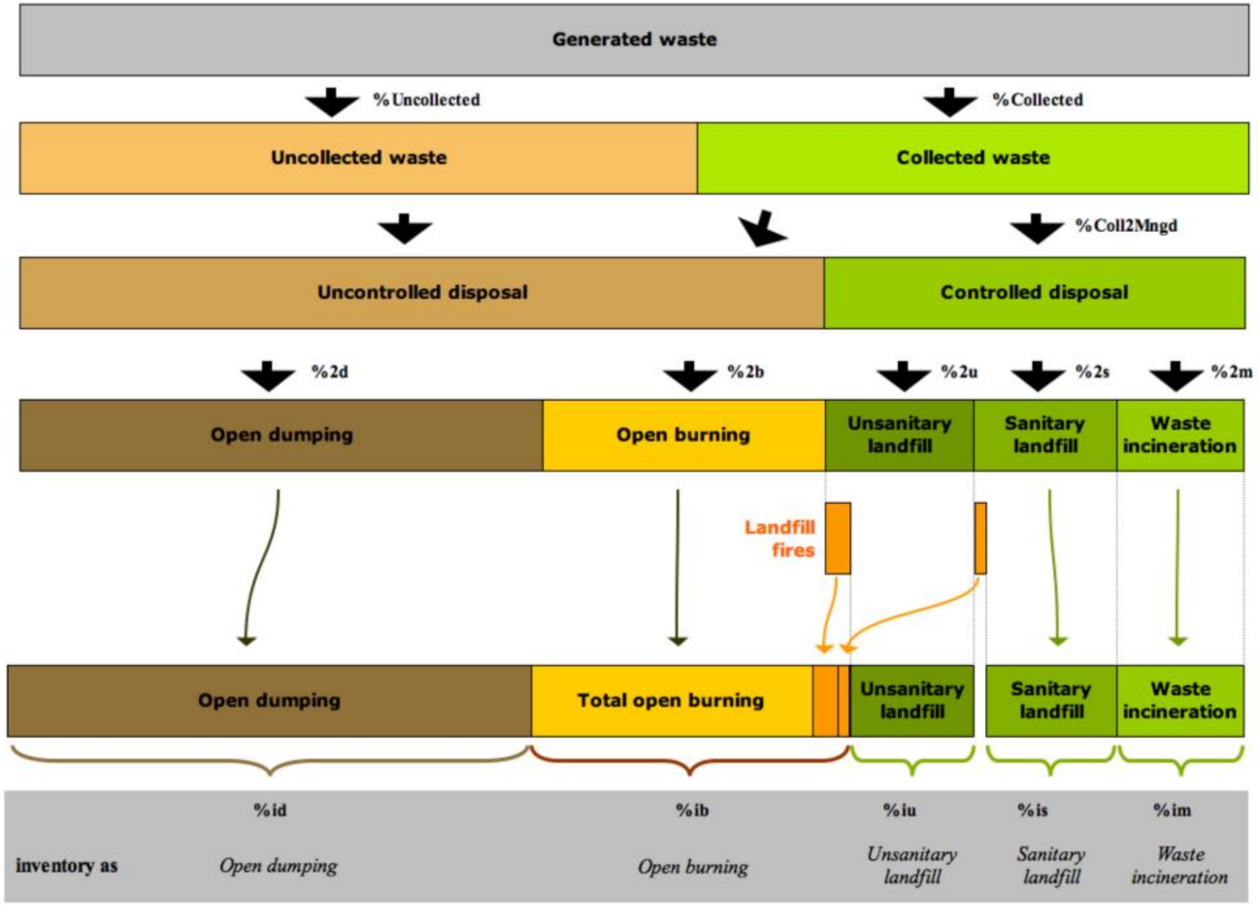
End-of-life waste management

This study aims to model the impact differences between **managed and mismanaged** waste tailored closer to humanitarian contexts.

The end-of-life impact for *a mix of plastic waste* reduces as below:

Method	GHG Emissions	Impact on Human Health
Open Burning	~HIGHEST~	~HIGHEST~
Municipal Incineration	-2.60%	-96.03%
Unsanitary Landfill	-93.80%	-99.40%
Open Dumping	-95.50%	-99.87%
Sanitary Landfill	-96.22%	-99.06%

Open burning creates maximum impact for both categories, but beyond that there are differences between climate change and human health on the specific magnitude of reduction.



Doka, G., 2018, Inventory parameters for regionalised waste disposal mixes

This study uses values for specific types of plastic wherever necessary, however the proportions of impact follow similar trends across the types of plastic product. This is therefore the standard impact implication for plastic products at end-of-life. Whenever possible, recycling is also modelled as a waste treatment option within the scope of the study.

NOTE: The methods listed above have differences in how long it takes for the plastic to be removed. It is part the LCA methodology that measurements are limited to a 100 years, therefore any further impact due to the degradation of plastic in landfills is not measured or compared with other methods of disposal.